# Observing System Simulation Experiments

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# Overview

- What are OSSEs (and OSEs)?
  - What are they useful for?
  - How are they designed?
  - What is the origin (NWP)?
- Two example OSSEs
  - One already executed
  - One in the planning stages
- How can the concept be generalized?
  - Aerosol, atmospheric composition
  - Ocean
  - Land
  - Climate

# OSEs

- **Observing System Experiments**
  - Typically aimed at assessing the impact of a given *existing* data type on a system
  - Relatively straightforward
  - Using existing observational data and operational analyses, the candidate data are either added to withheld from the forecast system, and the impact is assessed

  - Control run (all operationally used observations)
  - Perturbation run (control plus candidate data)
  - Compare!

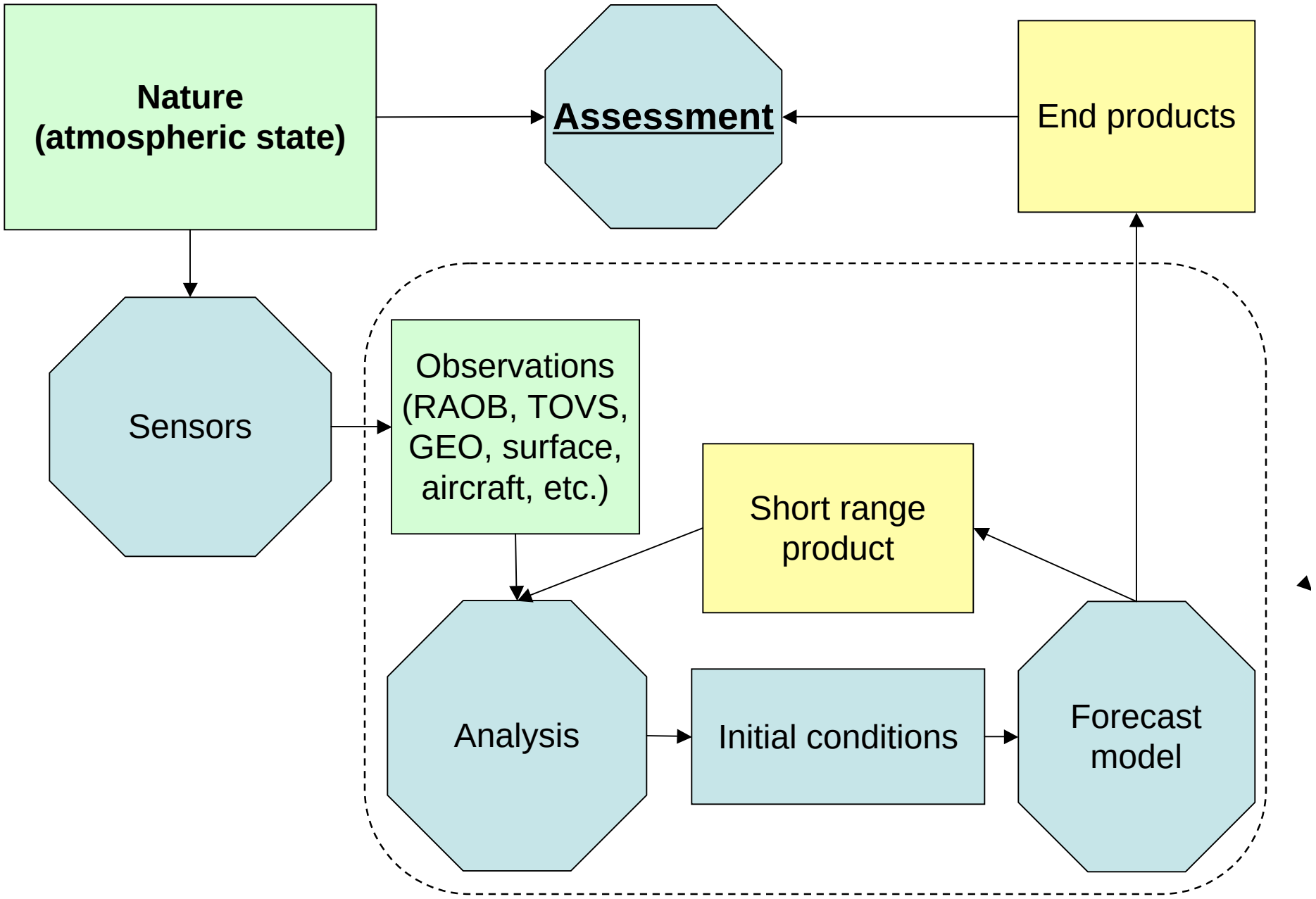
# OSSEs

- **Observing System *Simulation* Experiment**
  - Typically aimed at assessing the impact of a *hypothetical* data type on a forecast system
    - Not straightforward; EVERYTHING must be simulated
      - Simulated atmosphere (“nature run”)
      - Simulated reference observations (corresponding to existing observations)
      - Simulate perturbation observations
      - (object of study)
  - => Costly in terms of computing and manpower

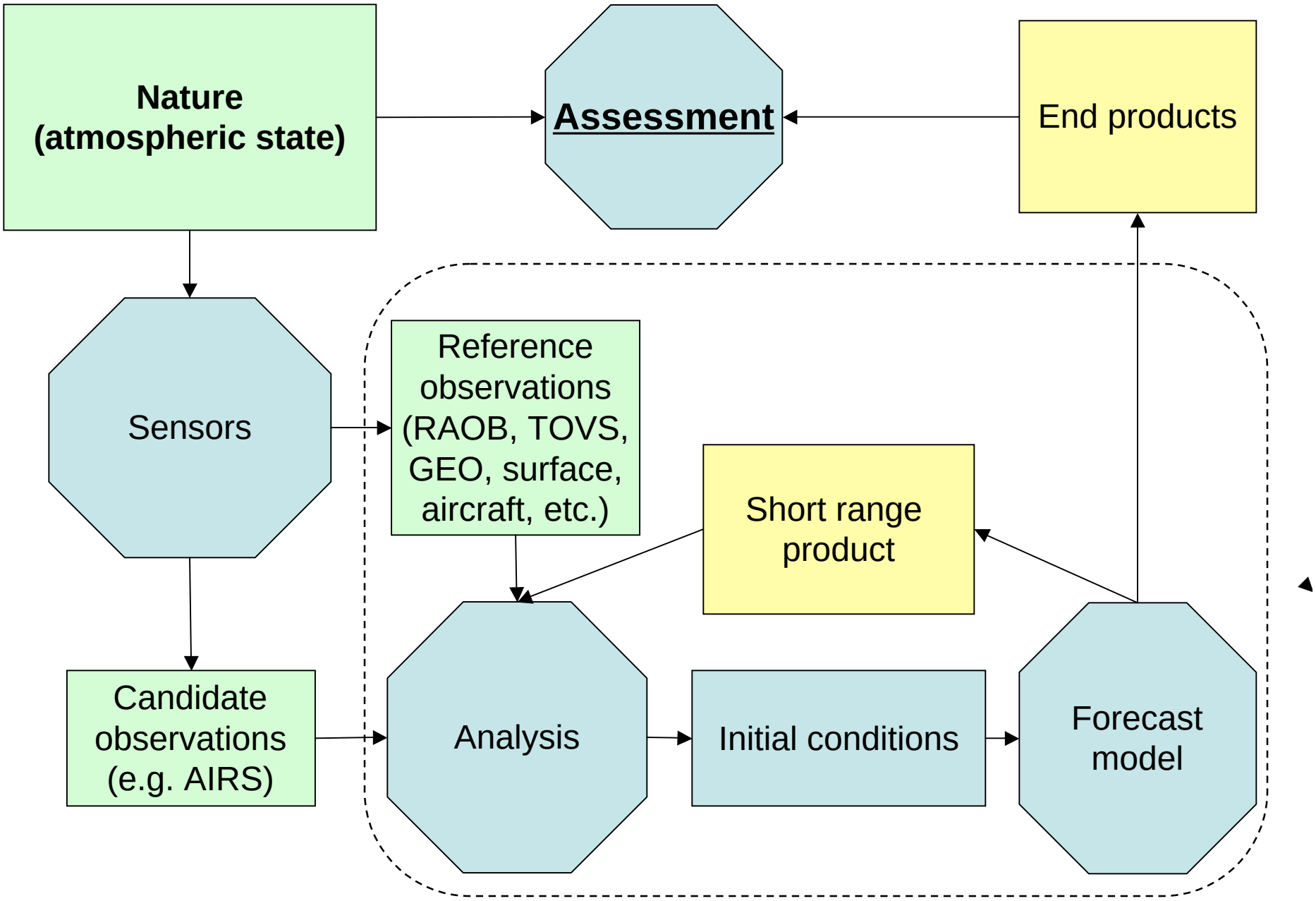
# *"Why can't you just use real atmospheric situations and real data?"*

- The goal of the OSSE is to test whether a given non-existing type of data could improve on the initial conditions; how would we do that?
  - *"You just simulate these new observations and add them to the assimilation"*
- We simulate them based on what?
  - *"Well based on the actual atmospheric state!"*
- But everything we know about the "actual state" is captured in the analysis using the observations we already have; we cannot add or create information simply by resampling our own imperfect estimate.

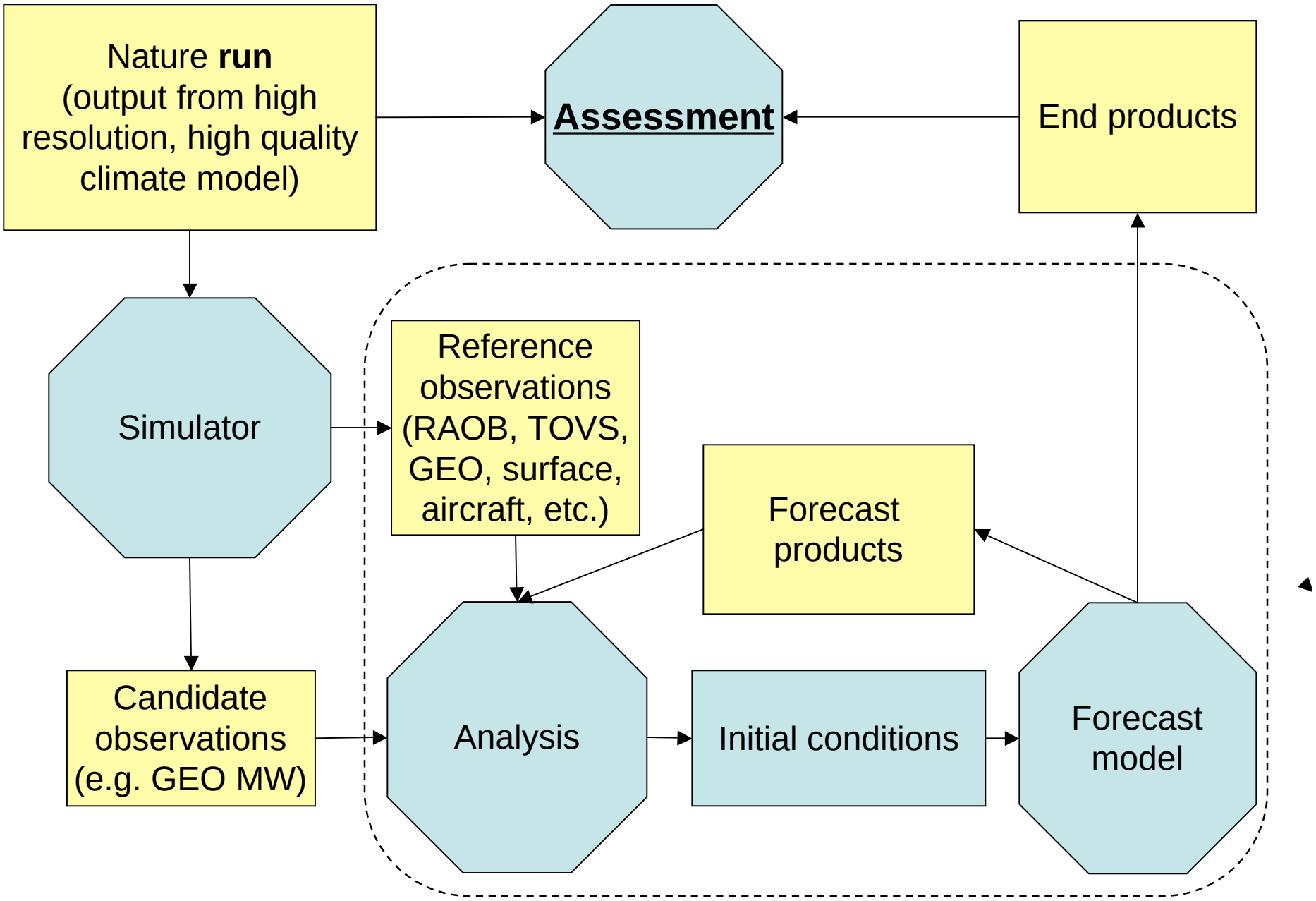
# Data assimilation



# OSE, conceptual model



# OSSE, conceptual model



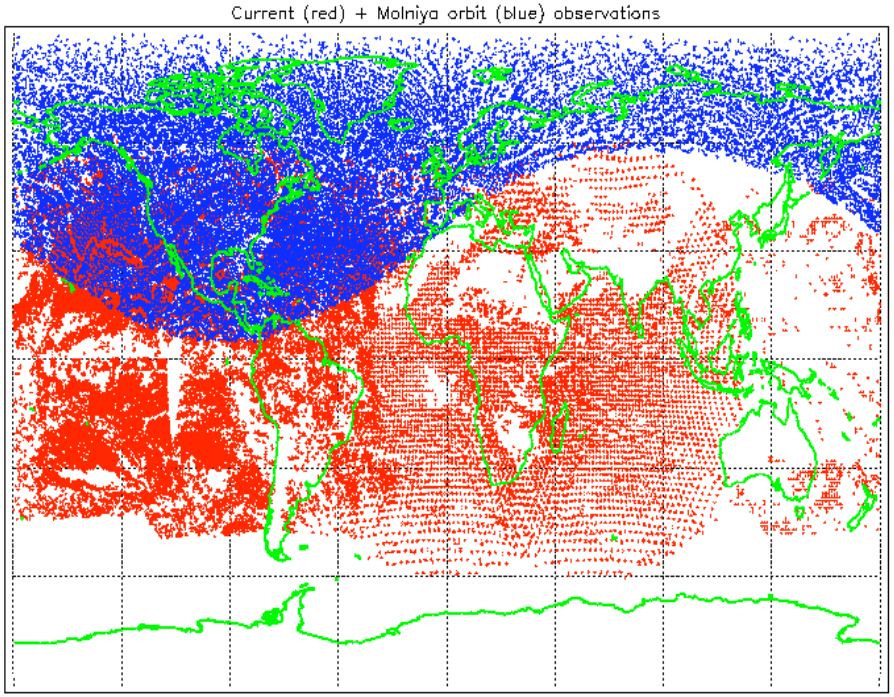
# Molniya OSSE

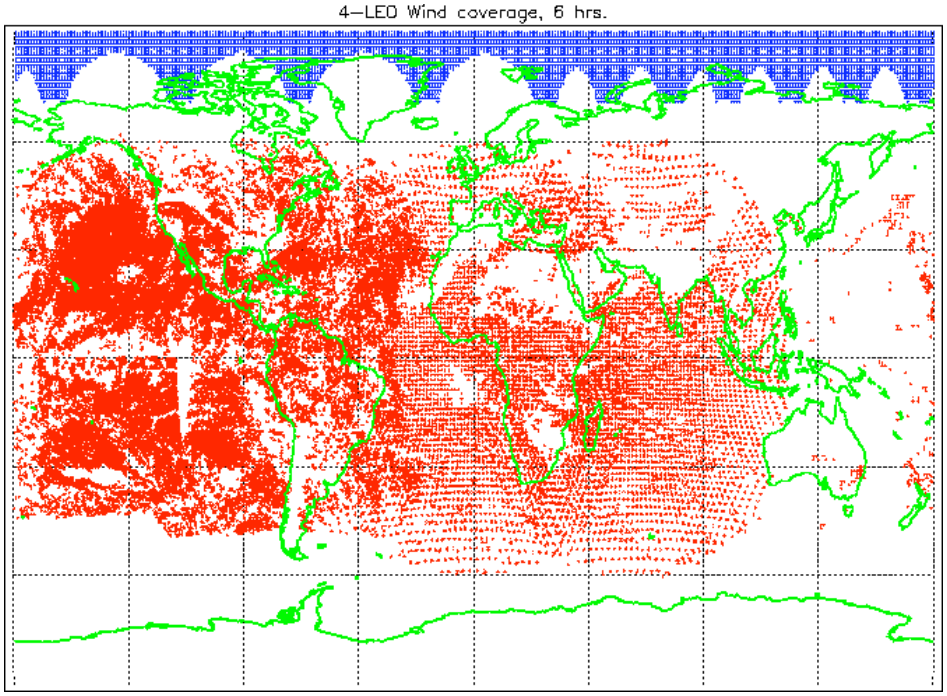
(Observing system simulation experiment)

GEOS-4; Atlas et al.

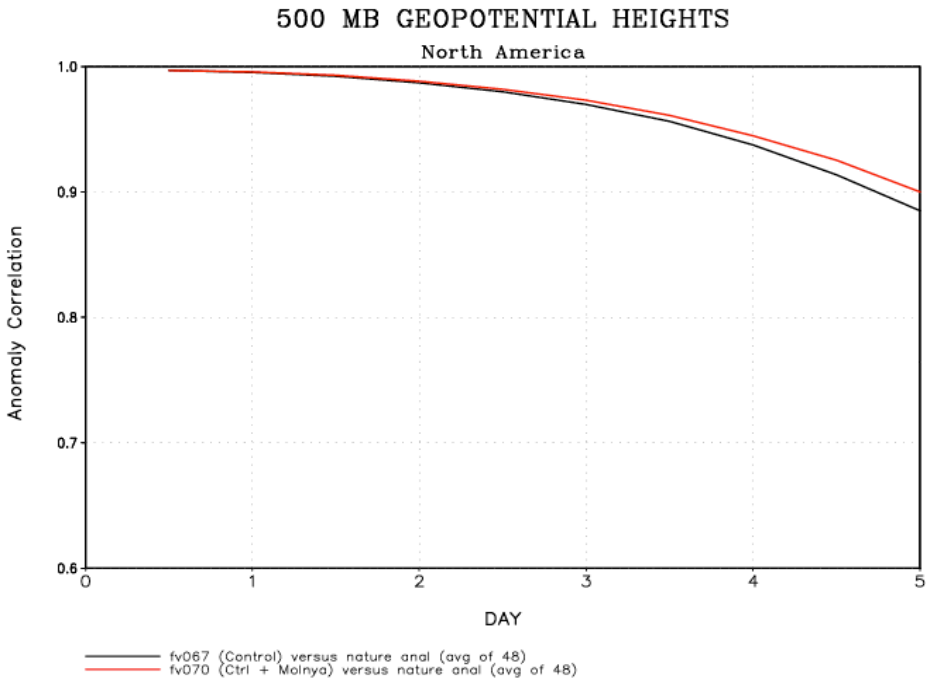
6-hour winds coverage, 4 LEO's ⇨

Apogee winds coverage, Molniya ⇩



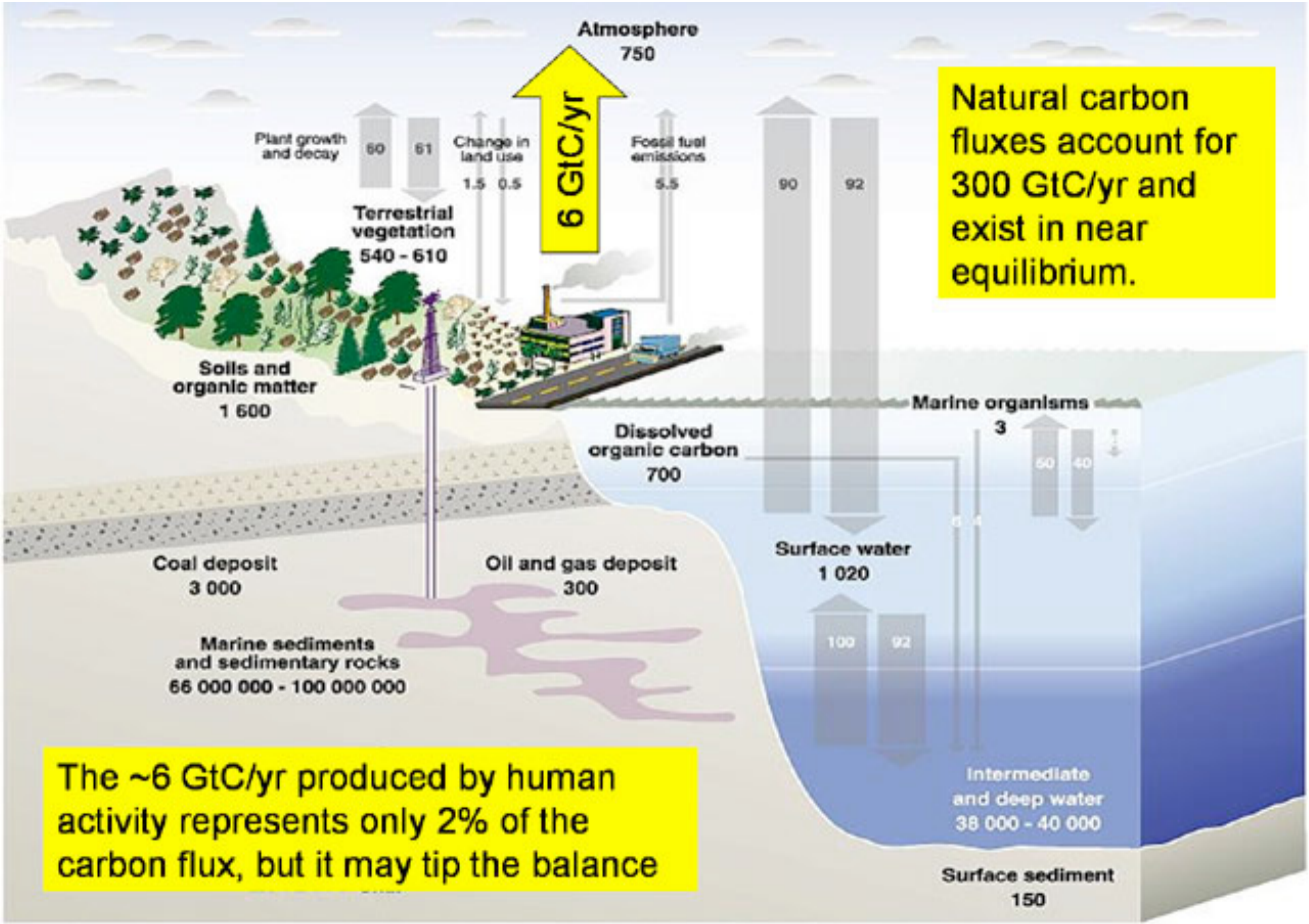

Forecast improvement over North America, 48 cases ⇨



# Orbiting Carbon Observatory

- Mission already in development under ESSP; slated for 2009 launch
  - *" …precise, time-dependent global measurements of atmospheric carbon dioxide (CO2) from an Earth orbiting satellite"* (JPL)
- Hyperspectral near-IR instrument; primary science data product is $CO_2$ column

- Two questions (based on discussions with Steve Pawson, GMAO)
  - Can we do source estimation from OCO? – what is the right strategy for assimilation?
  - Can OCO do surface pressure? – with what kind of accuracy impact?




Sources: Center for climatic research, Institute for environmental studies, university of Wisconsin at Madison; Okanagan university college in Canada, Department of geography; World Watch, November-December 1998; Climate change 1995, The science of climate change, contribution of working group 1 to the second assessment report of the intergovernmental panel on climate change, UNEP and WMO, Cambridge press university, 1996.

# OCO (I)

- Question
  - "What observations do we need and how do we need to assimilate them in order to estimate surface fluxes?"

- Ingredients
  1. Transport given by GCM and assumed to be perfect
  2. Imposed "best-estimate" fluxes
  3. Simulated OCO observations of the scenario given by 1. and 2.

- Using 1., attempt to recover 2. from 3.
  - This can iterated until the question is answered
  - e.g. data selection, density, cloudiness, radiance vs. retrieval

# OCO (II)

- Can OCO provide surface pressure observations at an accuracy that would be useful for NWP?
  - A “first” from space; global coverage over land
  - Relatively easy to define and execute OSSE
    - Simulate generic surface pressure observations with pertinent coverage and error characteristics
  - A positive answer would have substantial implications
    - for OCO: algorithm development, processing and dissemination (latency)
    - for the users:  new data type, benefits

# Extending the OSSE Concept Beyond NWP

NWP not the only area facing important decisions on observing system development

- Constituent OSSEs - monitoring and predicting air pollution; monitoring changes in greenhouse gases
- Ocean, land, climate, etc.
    - *poster by Wielicki et al.*

Conceptual barrier

NWP OSSE methodology is predicated on the existence of a well-defined prediction problem *with a known answer*

–"How does/would sensor X affect the skill in three-day hurricane landfall forecasts over CONUS?"

# Summary

- OSSEs are cumbersome and expensive
- BUT
  - Investment still represents a small fraction of overall cost of observing system
  - Can play a useful role at any phase in the development prior to launch
- OSSE methodology for NWP is well-developed (capability currently being redeveloped for GEOS-5 and GSF in collaboration with the Joint Center for Satellite Data Assimilation)
- OSSEs - or similar tools - needed for other disciplines/observing systems
  - Generalization of NWP-based concept is straightforward in some cases, may be impossible in others